

AN EFFECT OF REINFORCEMENT AND HEAT TREATMENT ON

AA7075 METAL MATRIX COMPOSITE – A REVIEW

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ABSTRACT

AA7075 is a combination with zinc as an essential alloying component. When contrasted with numerous different steels its quality is very similar. It has greater fatigue strength, however less protection from corrosion than numerous other Al alloy. This paper investigates the possibility of growing elite composites with low cost, for different applications like aviation and automobile. The impact of different reinforcements on the AA7075 based composite has been investigated. The mechanical properties, have been seen to be either practically identical or better after heat treatment to the as cast composites. It has been found from the past research that the nearness of the hard ceramic stage, for example, SiC, TiB₂, B₄C, Al₂O₃ effects direct strengthening of the composites. In view of the information from the previous research, the application region of AA7075 AMCs has been shown in the present review. It has been gathered that the hybrid composites give greater reliability and flexibility in the design of components depending upon the reinforcement and matrix material.

KEYWORDS: Aluminium Matrix Composite, Heat Treatment & Al 7075

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INTRODUCTION

An Earth-wide temperature boost and global warming is a genuine concern where it is driven to some extent by the exhaust gases from the vehicles. For both efficiency and discharges of exhaust gas control, decreasing the heaviness of auto bodies has been a main issue in the aviation and vehicle industry [1– 4]. For weight decrease, the utilization of lightweight metals, including Al and Mg alloys, is the fundamental thought via automakers. Specifically, the AA7075 has pulled in extensive consideration because of its high quality practically identical to numerous steels, along these lines prompting ultrahigh particular quality, high breaking strength, and protection from stress corrosion cracking [5]. For this kind of compound, precipitation hardening is the principle strengthening mechanism, though the hot usefulness workability toward becoming lower to improve the quality of the composite, as was appeared in Al– Mg– Si and Al– Zn– Mg alloys [6]

The ideal properties of aluminium are accomplished by alloying and heat treatment. These promote the formation of coherent precipitates which interfere with the development movement of dislocations and enhance its mechanical properties [7-10]. A standout amongst the most usually utilized aluminium alloys for auxiliary applications is the AA7075 because of its attractive properties, for example, high strength, low density, toughness, ductility and resistance to fatigue [11-14]. It has been broadly used in airplane auxiliary parts and other exceptionally stressed parts [15-19].

Another approach to enhance the mechanical and tribological properties of these aluminium alloys is to The addition of reinforcements into the metallic compound enhances the, specific strength, wear, stiffness, creep and fatigue properties compared with the traditional materials [20].

The wear properties of Al framework may antagonistically be influenced by the addition of hard ceramic reinforcements such as SiC, Al₂O₃, B₄C, TiB₂, and MoS₂ [21– 25]. As the including of ceramic reinforcement enhances the hardness of the composites, this makes it unsatisfactory for some of the applications. Further, the wear resistance of the three body wear has reduced due to an expansion in the counter face wear [26– 28]. Be that as it may, the ceramic particles in the Al alloy matrix are fundamentally required for holding the strength and stiffness of the composites. It is to be noticed that the ideal impact of reinforcement should to be kept up without sacrificing the mechanical and wear properties of Al composites [29].

The Al composite comprises of hard and brittle reinforcements that jut over the surface which carry on as roughness. The association of reinforcement with the counter face give more strength to the composites accompanied by the primary time of operation [30– 33]. This high strength of composite results low deformation of reinforcements and leads to the abrasion of the wear surface [34]. Under severe slip conditions, hard fortifications are expelled which diminishes the wear resistance of these composite materials. Under low load conditions, the removal of debris from the surface happens because of abrasive wear [35].

AA7075 is a matrix metal alloy, with zinc as the essential alloying component. It is sufficiently strong and has quality practically identical to numerous steels. In any case, it has lower protection from corrosion than numerous other aluminium alloys. The generally surprising expense confines its utilization for applications where less expensive alloy are required. The absolute stress corrosion resistances of the T173 and T7351 tempers make AA7075 a normal substitute for 2024, 2014 and 2017 in lots of the most basic applications. The T6 and T651 tempers have great machining property [36]. By strengthening with micro sized ceramic particles, the properties of the AA7075 can be enhanced [37]. The physical, mechanical and thermal properties of the AA7075 appear in Table 1. The chemical composition of the AA7075 appears in Table 2 [38-40].

Table 1: Properties of Al7075

Properties	Value
Density	2.81 g/cc
Hardness, Brinell	150
Ultimate Tensile Strength	572 MPa
Tensile Yield Strength	503 MPa
Elongation at Break	11%
Poisson's Ratio	0.33
Fatigue Strength	159 MPa
Shear Strength	331 MPa
Specific Heat Capacity	0.96 J/g-°C
Thermal Conductivity	130 W/m-°C
Melting Point	477 - 635°C
Annealing Temperature	413°C
Aging Temperature	121°C

Table 2: Chemical Composition of Al 7075

Element	Symbol	Composition % (wt) in Al 7075
Zinc	Zn	5.1 - 6.1
Magnesium	Mg	2.1 - 2.9
Copper	Cu	1.2 – 2.0
Ferrite	Fe	0.50 (max)
Chromium	Cr	0.18 - 0.28
Manganese	Mn	0.3 (max)
Silicon	Si	0.4 (max)
Titanium	Ti	0.2 (max)
Aluminium	Al	Remaining

The synthesis of MMCs can be accomplished by the aggregation of the reinforcement phase to the Matrix material. Certain appropriate methods are powder metallurgy [41], spray atomization and co-deposition [42, 43], plasma spraying [44,45], stir casting and squeeze casting [46]. In the engineering materials, the MMCs can be produced by an interesting method, for example, casting as it is economical and proposes numerous different alternatives for materials and preparing conditions [47].

Baradeswaran and Elaya Perumal [48] built up the AA7075 composites with B₄C as reinforcement by stir casting and found that the wear increased by increasing the volume of reinforcement. Zhang et al. [49] examined the tensile behaviour and fracture of AA7075/SiCp composites arranged by the spray deposition method. Doel and Bowen [50] created AA7075/SiC (5, 13 and 60 µm) composites and inferred that the elasticity was enhanced for 5 and 13 µm SiC particles than that of base alloy. Kalkanli and Yilmaz [51] arranged AA7075/SiC composites by squeeze casting and finished up 10 wt.% SiC reinforced composites demonstrated the greatest hardness, flexural and tensile strength in both as cast and heat treated conditions. Flores-Campos et al. [52] manufactured the AA7075 composites with carbon-coated silver nano particles and inferred that Vickers hardness (HVN) values were higher at higher Ag-CNP substance.

EFFECT OF REINFORCEMENT PARTICLES

There is no. of reinforcement materials that are used for the fabrication of composite. The selection of reinforcement materials depends upon the application of composite material. AA7075 are mostly used due to their light weight property and huge no of applications in defence and automobiles. To prepare composite several hard ceramic partials such as SiC, Al₂O₃, TiB₂, B₄C, industrial extracts Fly ash, agricultural product RHA, BA, CNT, etcare used. Many of the research have found improvement in the mechanical and tribological properties of the composite with AA7075. Chuandong Wu et al. [53] studied the effect of temperature range and holding time on mechanical; behaviour and microstructure AA7075/B₄C composite. The aluminium 7075 with 7.5% B₄C was created in composite by Plasma activated sintering method. The impact of temperature was examined in the range 450⁰C to 540⁰C. The impact of porosity on mechanical and microstructure properties had been considered. It was concluded in that the sintering at 530⁰C with a holding timefor 3 minutes prompts completely strong interface between AA7075 and B₄C, intense microstructure and comprise of most noteworthy yield strength, compression, hardness bending strength and fracture strength.

Lara et al. [54] watched the transform in mechanical and microstructure properties of Al7075/graphite composite. Composite were manufactured by hot extrusion. It was observed that mechanical and microstructure are function of graphite content. It was observed that the mechanical property can be upgrade by expanding both processing time and graphite content in the composite. It had been watching that there was a reverse connection between particle size and yield

strength it implies that the yield strength increments as particle size decreases. Lara et al. [55] contemplated the tribological behaviour of Aluminium 7075/graphite composite created by mechanical alloying and extrusion. The impact of processing time and graphite content focus on hardness and wear had been considered. The processing time changes from 0 to 10 hours and graphite content varies from 0 to 1.5%. The wear behaviour was examined in pin on disc apparatus on 20 and 40 N load and 0.367 m/s sliding speed. The composite comprises of 10 hour processing time and 1.5% graphite focus had homogeneous dispersion of particles in composite and change in hardness and wear resistance. Floras Campos et al. [56] researched the microstructure and mechanical behaviour of AA 7075/ silver carbide nano composite. The AA 7075 and carbon covered silver nano particles were prepared by milling process. The Al 7075-T6 was the base material it was tempered at 415⁰C keeping in mind the end goal to remove from T6 condition. The size of nano particles was 10 to 20 nm. The test specimens were made at the processing time of 0 to 25 hours. It was presumed that at less processing time the morphology was watched irregular yet with increment in processing time more equiaxed was watched. The most extreme hardness was seen as the convergence of 2% past that esteem the hardness was not further increase. Jiang and Wang [57] contemplated the mechanical properties and microstructure of nano AA7075/SiC composite by ultrasonic semisolid stirring. It was consolidated together with a specific end goal to scatter nano silicon carbide particles and separation the essential dendrites of the matrix. The Mechanical properties and microstructure of semisolid slurries and rheoformed chamber was additionally researched. The outcomes demonstrate that the ultrasonic treatment can well scatter the nano silicon carbide. It was watched that with increment in stirring time the measure of spheroidal of semisolid slurries increments. That implies the better semisolid slurries accomplished. High semisolid slurries was accomplished just when the temperature was 615 to 620⁰C upon 20 minutes of time. Ezatpour et al. [58] explored the microstructure, mechanical investigation and optical determination of aluminium 7075 based composite strengthened with alumina nanoparticles. The aluminium metal matrix composite was set up by traditional stir casting process. The poor dispersion of particles and high porosity was watched. To keep away from that porosity the nano size Al₂O₃ were infused within the presence of argon gas into liquid metal aluminium 7075. The mechanical performance was contemplated by tensile and compression tests, hardness, SEM, High Resolution Transmission Electron Microscopy and Optical Microscopy. It was inferred that the porosity is diminished after extrusion. The mechanical examination comes about affirmed that increase of Al₂O₃ nano particles amount and extrusion process enhance mechanical properties.

Chuandong Wu et al. [59] researched the impact of particle measure and spatial circulation of B₄C strengthening on the mechanical properties and microstructure aluminium composite. Aluminium 7075 alloy was utilized as matrix material. Boron carbide is used as reinforcement comprises of three sizes 56.9 µm, 4.2 µm and 2.0 µm. The wt% of Boron carbide is kept steady. The composite with coarse reinforcement had a homogeneous circulation of boron carbide particles and the composite with fine particles had agglomeration of the B₄C particles. The composite had littlest size reinforcement had most noteworthy yield strength quality and fracture strength. Kumar and Dhiman [60] examine the wear behaviour of the unreinforced AA7075 and hybrid aluminium metal matrix composite strengthened with the 7 wt. % of SiC and 3 wt.% of graphite manufactured by using stir casting method. It is surmised that the wear rate of the composite is lower than that of the unreinforced AA7075. The wear rate displayed expanding pattern with change of load. Saravanan and Kumar [61] state the impact of RHA on AlSi10Mg. The synthesis was done using stir casting, with various wt %age of RHA. The wt %age of RHA was 3,6,9 and 12%. SEM was used to investigate the scattering of RHA into AlSi10Mg. It was discovered that a UTS increased with increases RHA content. It was expanded up to 12% after that it began to reduce. The compressive strength was extended with increment wt %age of RHA. The hardness of composite increased with

increment in the RHA content. Narasaraju and Lingaraju [62] described the Hybrid Rice Husk and Fly ash Reinforced AlSi10Mg Composites. AlSi10Mg was utilized as matrix material. Rice husk ash and fly ash was utilized as reinforcement material comprises of 0.1 to 100µm. The reinforcement was 5% fly ash 15% RHA, 10% fly ash 10% RHA and 15% fly ash 5% RHA.. The elasticity expanded with increment in wt % of RHA and fly ash. Be that as it may, after 10% RHA and 10% fly ash in composite the elasticity begin diminishing. The hardness increases with increment in wt %age of RHA and fly ash. In any case, beyond 10% RHA and 10% fly ash in composite the hardness begin losing. It can be reasoned that the 10% RHA and 10% fly ash were the optimized value for this composite.

Raghavendra and Ramamurthy [63] investigated the tribological behaviour of Al7075/Al₂O₃/SiC particulate metal matrix composite made by stir casting process. The fabricate was done by keeping 3wt% of silicon carbide and in the wt% of Al₂O₃ as 3%, 6%, 9% and 12%. The density of composite was improved with increase in wt %age of reinforcement. The wear test was done on pin on disc wear tester. The results revealed that the wear properties increase with increase in wt %age of reinforcement. Veeresh Kumar et al. [64] had done examination of Al 6061/SiC and Al 7075/Al₂O₃ composites. The aluminium 6061 and aluminium 7075 is picked as base material for composite. The SiC is added in aluminium 6061 in wt% in 2, 4 and 6% and the addition of SiC is made in aluminium 7075 in wt% of 2%, 4% and 6%. The fabrication was done by Stir casting technique. It is presumed that the microhardness and elasticity increments with increment in wt %age of reinforcement particle. It is reasoned that the AA7075/Al₂O₃ would do well to mechanical properties then Al 6061/SiC. Karunesh G et al. [65] examine the mechanical properties of AA 7075/Al₂O₃ composite. The manufacturing of composites were finished by utilizing using Stir casting technique at various wt% of 0, 1, 3, 5 and 7%. The hardness testing was done by Brinell's hardness analyzer. The mechanical properties were additionally checked. The consequences of microstructure were demonstrated that the particles of Al₂O₃ scatter consistently in AA7075/Al₂O₃ composites. The outcomes uncovered that a definitive elasticity and yield strength begin diminishing with increment in wt% of Al₂O₃ in of AA 7075 composite. Singla and Mediratta [66] evaluate the mechanical properties of AA7075-Fly ash composite. The composite was created by Stir casting method. Magnesium was added to build the wetability of fly ash in AA 7075. The Charpy and Izod test are utilized to decide the impact strength of manufactured composite. The outcomes uncovered that toughness was extended with increment in fly ash. The density of composite was reducing with increment in fly ash content.

Table 3: Shows the Effect of Various Reinforcements on Mechanical Properties of al 7075 Composite

Composition	UTS (MPa)	Hardness	% of Elongation	Yield Strength (MPa)	Ref
Al7075+1%Gr+2%BA	259.3	87.3 BHN	6.7	176.84	[67]
Al7075+3%Gr+2%BA	265.4	92.4 BHN	6.4	183.83	
Al7075+5%Gr+2%BA	272.3	94.3 BHN	5.8	197.05	
Al7075+1%Gr+4%BA	267.3	87.7 BHN	6.3	180.68	
Al7075+3%Gr+4%BA	283.4	94.2 BHN	5.9	188.56	
Al7075+5%Gr+4%BA	290.3	95.4 BHN	5.2	199.29	
Al7075+1%Gr+6%BA	294.2	88.3 BHN	5.9	184.93	
Al7075+3%Gr+6%BA	296.3	95.4 BHN	5.4	190.53	
Al7075+5%Gr+6%BA	299.4	99.6 BHN	4.9	200.86	
Al7075	-	67 BHN	-	-	[68]
Al7075+3%B4C	-	77 BHN	-	-	
Al7075+3%B4C+5%SiC	-	82 BHN	-	-	
Al7075+3%B4C+10%SiC	-	85 BHN	-	-	
Al7075+3%B4C+15%SiC	-	88 BHN	-	-	

Table 3: Contd.,					
Al 7075	124.856	96 HV	6.862	98.118	[69]
Al 7075 + 10% SiC	181.694	120.5 HV	3.214	154.372	
Al 7075 + 10% Al ₂ O ₃	235.635	112.3 HV	3.333	210.514	
Al 7075 + 10 B ₄ C	303.846	138 HV	4.333	262.821	
Al7075	200.101	70.08 HV	4	25.631	[70]
Al7075+5%B ₄ C	260.556	105.15 HV	10	29.697	
Al7075+5%B ₄ C+3%RHA	235.278	115.18 HV	9	116.843	
Al7075+5%B ₄ C+5%RHA	220.076	121.42 HV	7.5	116.843	

EFFECT OF HEAT TREATMENT

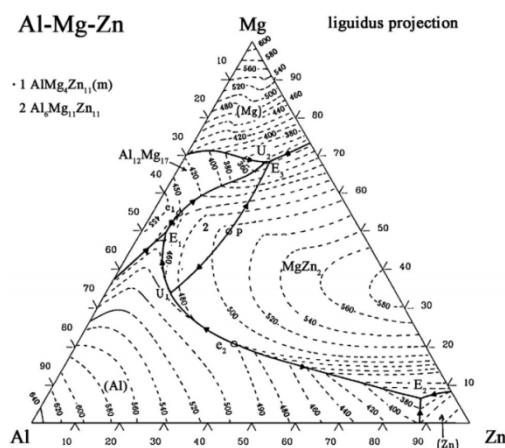
Matrix and composite exhibit an exceptional change in mechanical and tribological properties under heat treatment conditions when compared cast condition. To keep the high strength of the 7xxx aluminium alloy and upgrade their corrosion resistance in the meantime, novel heat treatments have been developed. [71 and 72]

The hardness of AA7075 composite age at 120 and 180°C was extended due to the increase in the nucleation site of intermediate precipitates. The heat resisting property of AA7075 was enhanced by squeeze casting in light of grain refinement impact, [73] keeping in mind the end goal to get high quality 7075 Al composite, heat treatment is a key procedure to enhance mechanical properties after the forming procedure. T6 heat treatment is one of the central points to improve mechanical properties of the alloy through an enhancement of both the solution heat treatment and aging conditions applied to the alloy. T6 heat treatment timetable of creating AA7075 were well-established at the solution temperature scope by 465– 490 °C and aging temperature of 120 °C [74]. Interestingly, dissolving solvent phases of the as-cast AA7075 ought to be done at temperatures lower than 465°C [75]. In addition, different aging times at 120°C for AA7075 have been proposed to be the peak-aged state of T6 heat treatment [76, 77].

The ideal solution heat treatment condition for the non-dendritic structure AA7075 was 450°C for 4 h. Age hardening was performed at temperatures of 120°C, 145°C, 165°C, and 185°C under different time spans. The peak aging condition was the fake artificial at 120°C for 72 h, at which a most elevated elasticity of 486 MPa with 2% elongation was recorded. This higher quality was caused by higher number density and better precipitate size of phase than other aging temperatures. The principle hardening phase was distinguished to be the phase while early nucleation of phase in the higher aging temperature resulted brought about lower strengths of the alloy. [78]

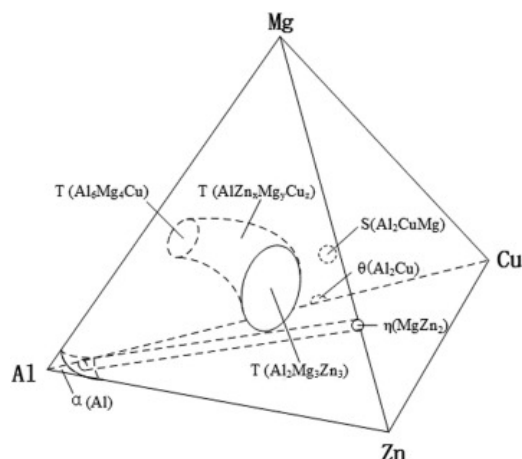
Phase Diagram and Phase Precipitation

The phase diagram for the 7075 alloy (Al- Mg-Zn) is given in figure 1 [79], and phase diagram of Al-Zn Mg-Cu alloy is shown in figure 2[80].



(a)

Figure 1: Phase Diagram for the Al-Zn-Cu-Mg System



(b)

Figure 2: Phase Diagram for the Al-Zn-Cu-Mg System

The phase in equilibrium with an Aluminum matrix Aluminium Alloy are allocated MgZn_2 [M-Phase], $\text{Mg}_3\text{Zn}_3\text{Al}_3$ [T-Phase] and Mg_5Al_3 [β -Phase]. The central stage goes in phases from MgZn_2 to $\text{Mg}_4\text{Zn}_7\text{Al}$. The T-Phase has a broad range of composition, from 74% Zinc-16% Magnesium to 20% Zinc-31% Magnesium. The phase appears to be exactly when the magnesium content is broadly more prominent than the Zn content. Such composites are strengthened basically by Mg in solid solution. Precipitation hardening of alloy with Zn in wealth of Mg occurs in the plan zones through insightful precipitates to the M-Phase. Quaternary alloys contain copper, magnesium and zinc. The M-Phase composition of action goes in the quaternary structure from MgZn_2 to CuMgAl and may be depicted as $\text{Mg} [\text{Al}, \text{Cu}, \text{Zn}]_2$. The extent of composition for the T-Phase is from that of Al-Mg-Zn ternary to that of Phase relegated CuMg_4Al_6 and may be depicted as $\text{Mg}_3 [\text{Al}_2\text{Cu}, \text{Zn}]_5$. A third stage is CuMgAl_2 [S-Phase], with a little extent of composition. The CuAl_2 appears to be simply if copper is widely in excess of Mg. A couple of non equilibrium invariant melting reactions are knowledgeable about the high strength quaternary alloys. [81]

Al-Mg-Cu-Zn phase diagrams shown in Figure 2 η (MgZn_2), θ (G. P. zone, Al_2Cu), S (Al_2CuMg) and T ($\text{AlZn}_x\text{Mg}_y\text{Cu}_z$) may exist in the Al-Zn-Mg-Cu alloy as it depicts in the phase diagram.

Veeravalli Ramakoteswara Rao et al [82] examined the sliding wear of aluminum matrix composites (AA7075–TiC) have been researched under dry sliding wear conditions. The Aluminum Metal Matrix Composites (AMMCs) are created as AA7075 matrix metal and TiC particulates of a normal size of $2 \mu\text{m}$ as reinforcement particles through stir casting method. AMMCs considered are contained 2–10 wt.% of TiC particles in both as cast and heat treated (T6) conditions. Every one of the composites showed better mechanical properties (hardness, elasticity and level of extension) than the matrix metal in both the conditions. The wear tests were performed at a sliding speed of 2 m/s, sliding distance 2 km and at load of 20 N. The wear resistance of the composites extended with increasing weight percentage of TiC particles, and furthermore the wear rate was quite less for the composite material contrasted with the matrix material. A definite examination in as-cast condition and T6 state of the AMMCs was done utilizing SEM keeping in mind the end goal to discover the impact of TiC particles in the AMMCs. It has been watched that under T6 heat treatment condition, alloy and composite demonstrated critical change in mechanical and tribological properties when thought about in as cast condition. Figure 3 demonstrates the change in the hardness and reinforcement of TiC at cast and heat treated (T6) conditions. It can be seen that hardness of the composites is substantially higher than that of the alloy. An expanding

pattern in hardness is seen in as cast condition from 98.4 to 118.6 VHN, and also in heat treated conditions from 181 to 202.1 VHN for AA7075 matrix material upto 8 wt.% of TiC strengthened composite.

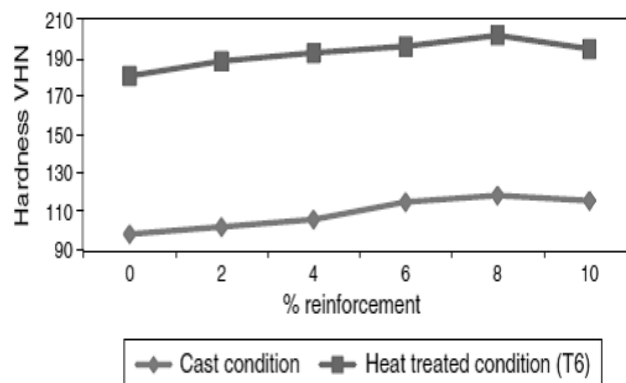


Figure 3: Vicker Hardness Behavior of Al7075/TiC Composites for Cast and Heat Treated Condition

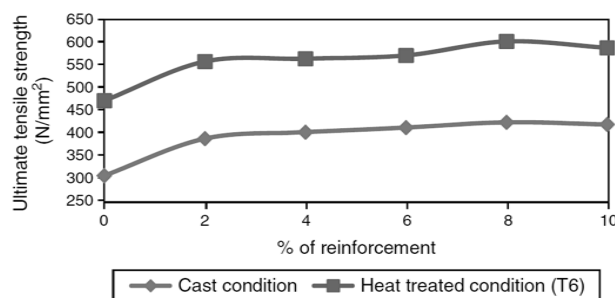


Figure 4: Comparison of Ultimate Tensile Strength with Increasing % of Reinforcement in Cast and Heat Treated Conditions

Figure 4 demonstrates the impact of TiC on the elasticity of the composite acquired in tensile test. The tensile strength is observed to be enhanced with including TiC particles. An expansion in 130 MPa quality is watched for 8 wt.% TiC particles took after by T6 warm treatment. The wear rate of the AA7075 material and its composites with TiC particles at heat treatment and as cast condition are appeared in Figure 5 for a given wt.% of reinforcement, the heat treated condition offers higher wear properties.

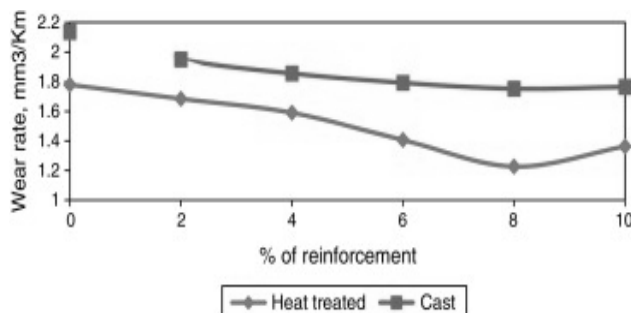


Figure 5: Effect of wt.% of Reinforcement on Wear Rate for Cast and Heat Treated Condition

Kalkanli and Yilmaz [83] investigated heat treated SiC/AA7075 composites as per ASM T6 heatm treatment conditions, trailed by solutionization at 480°C for 55 to 65 min. At that point, they were extinguished and precipitation heat

treated at 120°C for 24 h. Kumar and Dhiman [84] performed T6 heat treatment of SiC/Gr/AA7075 hybrid MMC, in which the solution treatment was done at 490°C for 2 h, trailed by water quenching, and artificial aging done at 120°C for 20 h.

CONCLUSIONS

An attempt has been made to lay out the impact of different reinforcement of aluminium composite, giving different impacts of particles has been talked about briefly, and emphasis has been given to various key focuses, for example, determination of weight or volume portion of reinforcement in the composite, heat treatment for composites of AA7075 has been outlined briefly, and following observations made:-

- The stir casting procedure is viewed as a amongst the most utilized fabrication process for AA7075 matrix composite.
- The composite has smaller size, reinforcement which has more yield Strength as compare with composite having extensive size reinforcement particles.
- There were decreases in mechanical properties like tensile strength, compression strength, hardness with the addition of graphite as support.
- There were increments in mechanical properties like tensile strength, compression strength, hardness with the addition of hard particles like B₄C Al₂O₃ and SiC.
- Heat treatment of the aluminium alloy and composite prompts precipitation hardening and most extreme hardness is acquired at top peak aging time of 24h. On this line it is normal that less wear rate could be acquired at peak-aging time for 24h.
- Solution heat treatment for 8 hours at 440 °C brought about a noteworthy change in the compound quality.

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